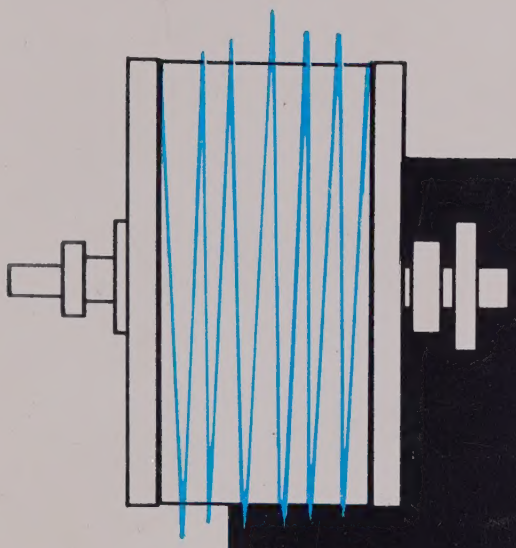
4636 4609 4634 X-Y

Dept 605



DYNAMOMETER OPERATING INSTRUCTIONS

MAGTROL, INC.

Dept 605

MAGTROL, INC.
70 GARDENVILLE PARKWAY WEST
BUFFALO, NEW YORK 14224

MAGTROL, INC.
~~240 Seneca Street~~
Buffalo, New York

MAGTROL DYNAMOMETER and ASSOCIATED EQUIPMENT

TABLE OF CONTENTS

			Page
1.	Dynamometers		
1.1	General Description	.....	1
1.1.1.	Operating Principle	.....	1
1.2.	Set Up	.....	2
1.2.1.	Motor Attachment	.....	2
1.2.2.	Shaft Alignment and Coupling Considerations	.....	2
1.3.	Magnetic Salient Pole Effect	.....	4
1.4.	Accuracy	.....	4
1.4.1.	Geometric Dial Lay-Out	.....	4
1.4.2.	Mechanical Friction	.....	5
1.4.3.	Windage	.....	5
1.5.	Calibration	.....	6
1.5.1.	Beam	.....	6
1.5.2.	Weight	.....	7
1.6.	Power Dissipation	.....	7
1.7	Maximum Speed	.....	9
1.8	Maintenance	.....	9
1.8.1.	Lubrication	.....	9
1.8.2.	Cleaning	.....	9
1.8.3.	Disassembly	.....	10
2.	Model 4636 Power Supply		
2.1.	General Description	.....	13
2.2.	Circuit Description	.....	13

Page

4. Tachometer Pick Up

4.1.	General Description	.....	23
4.1.2.	Exciter Lamp	.....	23
4.2.	Frequency Adjustments	.....	23

5. Model 4609 Speed Controlled Power Supply

5.1.	General Description	.....	24
5.2.	Control Functions	.....	25
5.2.1.	Maximum Motor Speed	.....	25
5.2.2.	Speed Control Damping	.....	26
5.2.3.	Stabilized Control	.....	27
5.2.4.	Dynamometer Brake ON-OFF	.....	27
5.3.	Operating Instructions	.....	28
5.4.	Maintenance	.....	29

6. Model 4634 X-Y Programmer

6.1.	General Description	.....	30
6.1.1.	Speed	.....	30
6.1.2.	Torque	.....	30
6.1.2.1.	Effects of Temperature	.....	30
6.1.2.2.	Load Cell Balance and Compensation Controls	.....	31
6.1.2.3.	Load Cell Drift Compensation Set Up	.....	32
6.1.3.	Inertial Error Compensation	.....	33
6.1.3.1.	Inertial Error Compensation Adjustment	.....	33
6.2.	Set Up and Operating Procedure	.....	34
6.3.	Oscillations and Eratic Behavior	.....	38
6.4.	Alignment	.....	39
	MAGTROL WARRANTY	.....	40

SECTION 1 DYNAMOMETERS

1.1 General Description:

The following Dynamometers are absorption instruments, designed to apply and indicate a load to a motor. This load is controllable and, typically, reads out directly in oz. in., or may be in other Engineering units. The basic operation and assembly of the instrument are essentially simple, and the following drawing illustrates a typical unit, and piece part identification. Refer to Figure 1.

1.1.1. Operating Principle:

All Dynamometers are equipped with a Hysteresis Brake. This differs from the more common Eddy Current Brake in that the torque developed in a Hysteresis Brake is quite independent of slip speed.

Essentially, when the rotor is forced to operate in a precisely defined magnetic field, it resists rotation, dependent on the strength of this field. This basic fact, as applied to the Dynamometer, accomplishes two functions:

One, it applies a load to the motor, forcing it to work.

Two, the suspended brake assembly, which is the reaction member, tries to rotate with the motor.

However, being weighted at the bottom, it is able to rotate only as far as the brake torque is able to lift this weight. If rotation of the input shaft is maintained, a condition of slip within the brake assembly exists.

The value of torque will be indicated on the integral torque dial. This torque is dependent on field strength which, in turn, is dependent upon applied current. Thus, the "Torque Adjust" control on the power supply, or other associated equipment, merely adjusts the applied current to the brake coil.

1.2. Set Up:

After all packing materials are removed and the Dynamometer carriage and shaft are free, the unit should be leveled where it is intended to operate. A leveling bubble is provided on the base plate, and should be used to level front to rear. Use the hair line indicator for leveling sideways, such that with nothing installed on the shaft, the torque reads "0".

1.2.1. Motor Attachment:

Since electric motors assume an almost infinite variety of sizes and shapes, it is practical only to cover undesirable effects of poor coupling techniques. Naturally, whatever torque is indicated on the Dynamometer is also present on the motor itself. Therefore, torsionally secure mounting is mandatory.

1.2.2. Shaft Alignment and Coupling Considerations:

Shaft alignment and coupling considerations are important from a stand point of vibration, read out accuracy and bearing life. Since perfect shaft alignment is virtually impossible, a flexible coupling is essential

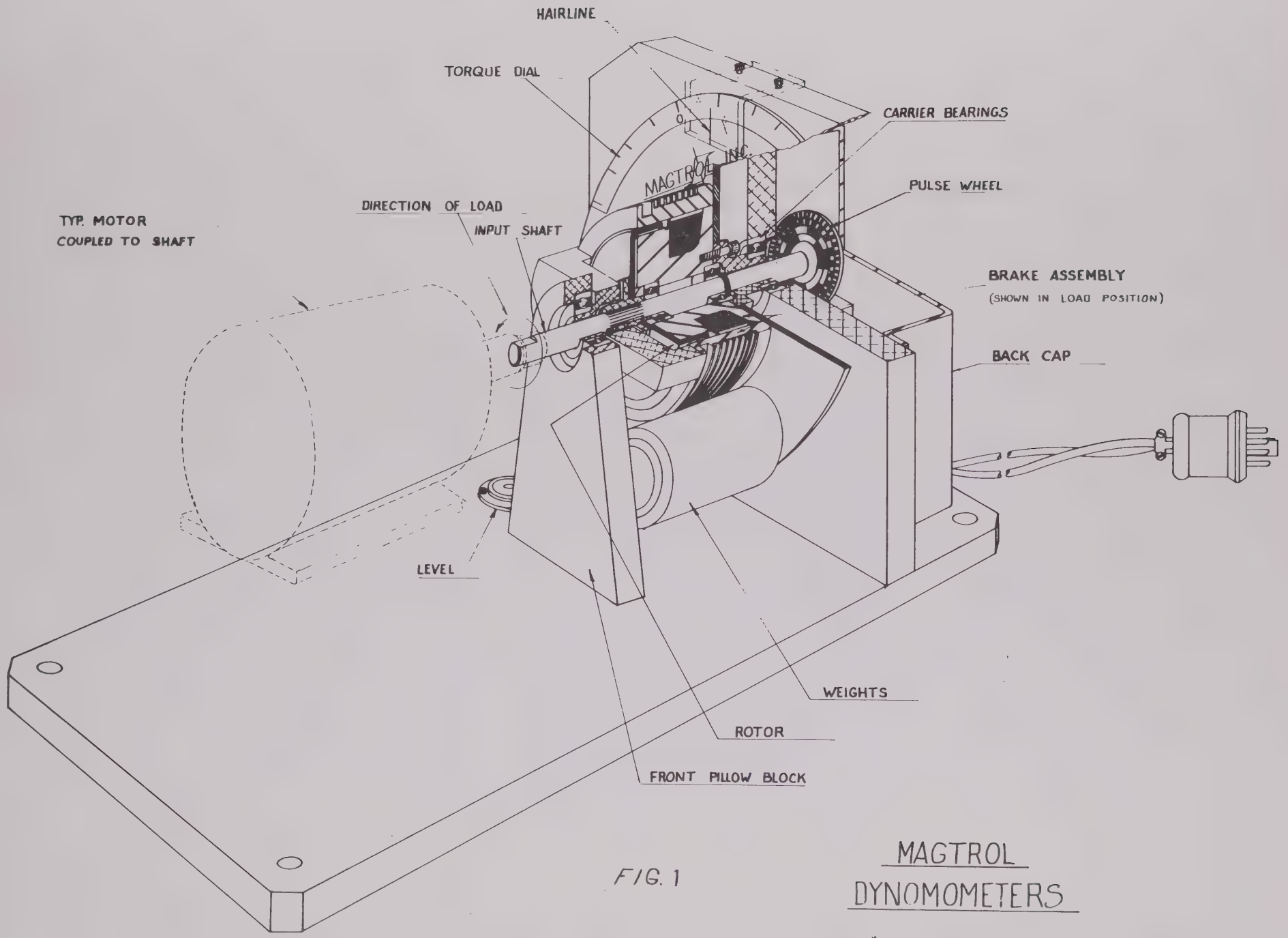


FIG. 1

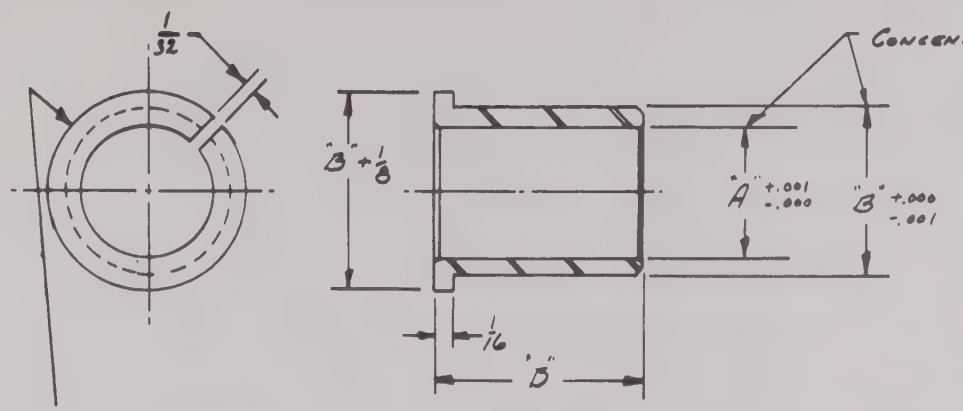
MAGTROL
DYNOMOMETERS

DRWG.* SK-1005

in most applications. It is desirable to use one which will tolerate both a modest amount of straight mis-alignment, as well as radial eccentricity. There are a wide variety of couplings available, and many are satisfactory for this service. One we have found suitable is "Lord Manufacturing Co., Erie, Pa., Type J-1211." Specify shaft size required. All Dynamometer input shafts are in standard inch sizes. Refer to the following table.

DYNAMOMETER SHAFTS		
DYN. MODEL	FRACTIONAL	DECIMAL
HD - 106	1/8"	.1245/.1250
HD - 400	1/4"	.2495/.2500
HD - 500	3/8"	.3745/.3750
HD - 600	1/2"	.4995/.5000
HD - 700	1/2"	.4995/.5000
HD - 705	1/2"	.4995/.5000
HD - 800	1"	.9995/.1000
HD - 805	1"	.9995/.1000

Rarely will the motor shaft and the Dynamometer shaft be the same size. Therefore, it may be necessary to adjust either one or the other to the coupling. A practical way would be to install a bushing of the style shown in Fig. 3. to adapt either shaft to the coupling. See Figure 3. These bushings are available from Magtrol, Inc. For special shaft diameters, specify shaft diameter and tolerance.



LOCATE IN COUPLING SUCH THAT SET SCREW BEARS AT ARROW

— STANDARD STOCKED BUSHINGS —

PART Nº	"A"	"B"
4670	.093	1/4
4671	.156	1/4
4672	.187	1/4
4673	.312	3/8
4674	.437	1/2

NOTE:

000 SIZE SHAFTS TO BE ORDERED AS SPECIALS, WE STOCK BLANKS FOR SUCH PURPOSES.

—	STEEL	—	—	—	—

TOLERANCES: FRACT. - ±1/64 .XXX - ±.005 .XX - ±.010° ANG - ±1/2°

XX SURFACE FINISH MICROINCHES

DRAWN | CHECKED | APPROVED

DATE 10-26-62

BY S.T.

TITLE: COUPLING BUSHINGS

MAGTROL, INC.

240 SENECA ST. BUFFALO 4, N.Y.

DWG. NO. 40 4669

LETTER	DATE	BY	ENG'R. CHG. NO.	CHANGE

REVISIONS

FIG. 3.

1.3. Magnetic Salient Pole Effect:

This is a condition prevalent to all Hysteresis Brakes. It is caused by imposing a field, in the absence of rotation, and subsequent removal of the field. This action establishes poles on the permanent magnet rotor. These poles react by resisting and alternately supporting rotation, as they pass a tooth form. When inertia is present, however, the action and reaction cancel themselves and impose no resistance to rotation as such. Therefore, with speed they reflect no minimum value, and have essentially disappeared.

Their complete removal is a simple procedure. Do not decrease the "Torque Adjust" from a given point, without rotation. Rotation may be in the form of oscillating the input back and forth by hand, while simultaneously decreasing the torque control.

1.4. Accuracy:

Since no springs, dampers, or other mechanical linkages are used in the Torque Indicating System of these units, it is not subject to long or short range drift of basic calibration accuracy. The units are to an accuracy of better than 1% on all ranges and this basic accuracy will never be lost. The accuracy of the system is a function of three things.

1.4.1. The Geometric and Mechanical Accuracy of the Torque Dial Layout:

The Torque Dial on all Dynamometers is photo reproduced on an aluminum material from a master using 2:1 Engine Divider layout. To date, this is

the only consistently accurate system we have found to reduce the radial division error to less than .002" at the calibration base circle. Additionally, the division width of the lines, and of the hairline in register with it, is approximately .003". This system has an inherent layout and registration accuracy of better than .1%.

1.4.2. Another source of error is Mechanical Friction in the Pendulum Swing Assembly.

The Mechanical friction problem is one of friction drag in the special stainless steel carrier bearings, plus the lead wire torque drag in the flexible leads from the Brake Assembly to the terminal block. The total torque of these two sources is usually so small that it cannot be read on the smallest torque scale, but it may be easily checked by noting the maximum reading either side of "zero" on the dial that the unit will support when standing idle, adding these two readings and dividing by two (2).

1.4.3. Dynamic Windage Error:

Dynamic windage error is a function of the speed at which the unit is operated and occurs because the rotor of the Brake Assembly generates currents of air, which impinge on the brake stator reaction member. If this effect were all tangential to the rotor surface, the resultant torque reaction would be against the brake stator in a manner that the error would be zero, since the torque reaction would be read as a component of the total torque reading.

However, due partially to the centrifugal pumping action of the rotor, and partly due to toothed outer construction of the brake stator, a portion of the air moved by the rotor is dissipated as pumping loss, requiring torque which is not compensated in the Torque Reading System. This error may generally be ignored, since it occurs only at very high speeds.

Note:

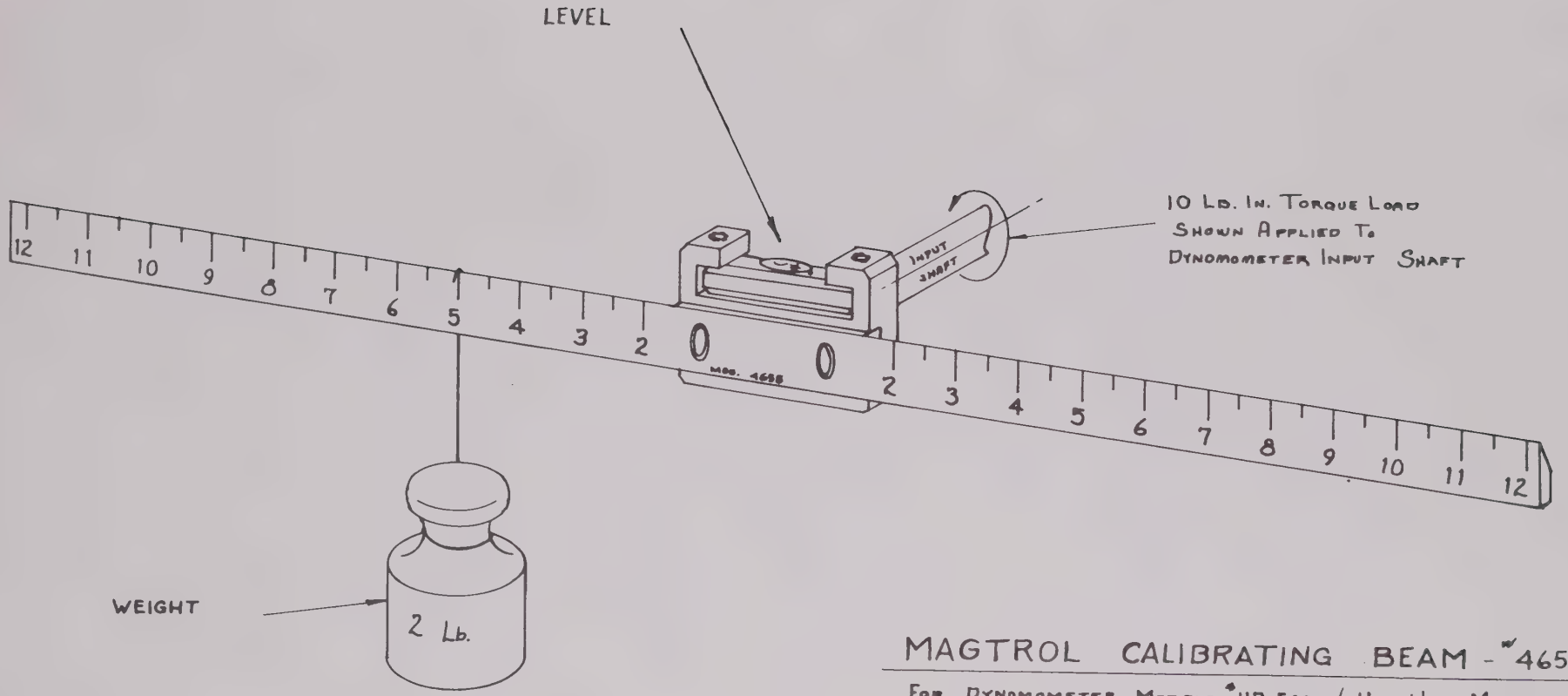
We do not install viscous, or Eddy-Current dampers into the swing assembly, since it is unavoidable to install them without introducing a finite component to torque error. For this reason, some mechanical oscillation may be observed occasionally when establishing a torque setting. An operator soon acquires experience and "feel" of the unit, however, and learns to damp this oscillation.

1.5. Calibration of the Counterweight:

The only error involved is usually small enough to be neglected, since nearly all torque ranges are calibrated to a full scale accuracy of better than 1%. The calibration of any unit may be checked, and the procedure is simple.

1.5.1. The most accurate method of calibrating a Dynamometer is with a beam and dead weight. To accomplish this it is necessary to have a balanced and structurally rigid arm, which will precisely fit the shaft, and be calibrated in inches.

This part is available from Magtrol, Inc. upon quotation. Refer to this


LEVEL
10 LB. IN. TORQUE LOAD
SHOWN APPLIED TO
DYNOMOMETER INPUT SHAFT
INPUT
SHAFT
MOD. 4655
12 11 10 9 8 7 6 5 4 3 2 0 0 2 3 4 5 6 7 8 9 10 11 12
WEIGHT
2 Lb.

MAGTROL CALIBRATING BEAM - #4655

FOR DYNOMOMETER MODELS #HD-500 & UP, USE MODEL #4665 FOR SMALLER DYNOMOMETERS.

#SK-1006

FIG 4

as part No. 4655. Specify Dynamometer size or serial number.

1.5.2. Utilizing good quality calibrated weights, such as "Ohaus Scale Corporation, Union, New Jersey." A precise distance weight relationship may be realized. Please refer to the following drawing: (Figure 4.)

EXAMPLE: 2 pounds at a distance of 5 inches is equal to a torque of 2 lb. x 5 in., or 10 lb. in. To convert to ounce inches, 16 ounces to the pound or 10 x 16 equals 160 oz. in.

Note:

Beam must be exactly horizontal, with load attached.

1.6. Power Dissipation:

All Magtrol Dynamometers are absorption types. Naturally, with high torque and high speed, there are ultimate limits to which the equipment may safely absorb power in the form of torque and speed.

The result of power absorption is temperature rise. The actual power absorption member is the rotor portion of the Brake Assembly.

Due to the close proximity of the rotor to the pole and case assembly, heat transference into these members is rapid; therefore, little thermal gradient exists. This design feature aids the temperature problem since there is now a mass for "heat sinking."

The criterion for establishing the maximum temperature rise is the Dynamometer coil and bearings. The maximum operating temperature has been

conservatively rated at 100° C. Since "Rate and Mass" are involved, this upper limit may occur by either low power input for a long period of time, or high power for a short period of time.

To more adequately utilize the instruments for high power inputs, a logical method for indicating the temperature rise is by graphic analysis. The following are a series of Curves of Watts input Vs Time. From a knowledge of torque and speed, or H.P., watts may be readily determined by the following formulas:

$$1 \text{ H. P.} = 746 \text{ Watts}$$

or in the case of torque and speed

$$\text{H. P.} = \frac{Q \times N}{5252}$$

Where Q = lb. ft.
N = R.P.M.

or a less accurate, (.8%) error, but more simple formula:

$$\text{H.P.} = Q \times N \times 10^{-6}$$

Where Q = oz. in.
N = R.P.M.

or 1/10H.P. = 100 oz. in. at 1000 R.P.M.

EXAMPLE: HD 700 Dynamometer and
1/4 H.P. Split Phase Motor

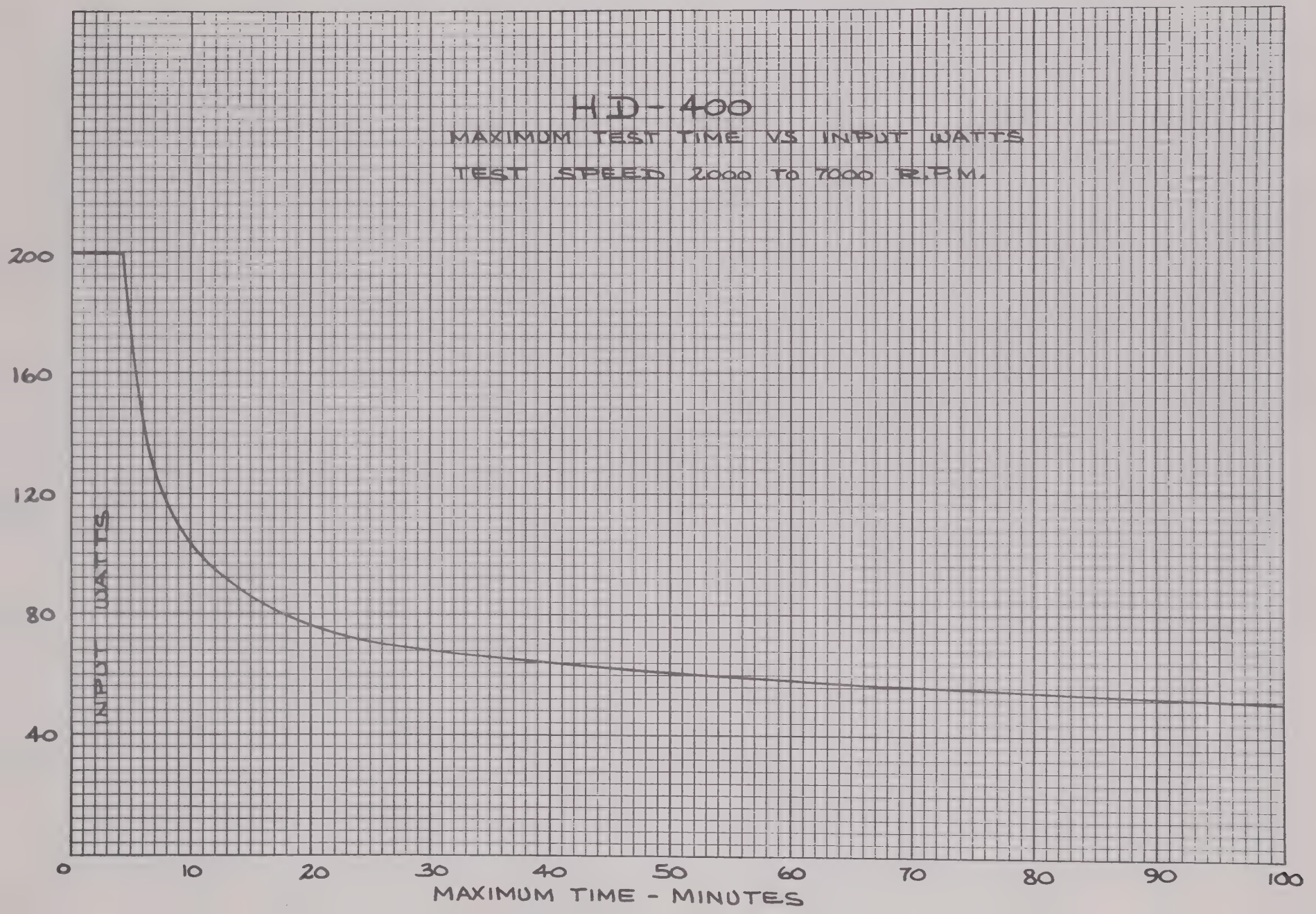
However, this motor actually developes 325 oz. in. at 1710 R.P.M. just before stall. Therefore:

$$\text{HP} = 325 \times 1710 \times 10^{-6}$$
$$= .55 \text{ H.P.}$$
$$\text{Watts} = .55 \times 746 = 410$$

Referring to the curve for the HD700, we see that the instrument will absorb 410 watts for 16 minutes, with a resultant temperature rise of 75°C, maximum

BRUNING 40-8500
10 X 10 TO THE INCH
CHARLES BRUNING COMPANY, INC
MADE IN U.S.A.

L.P.



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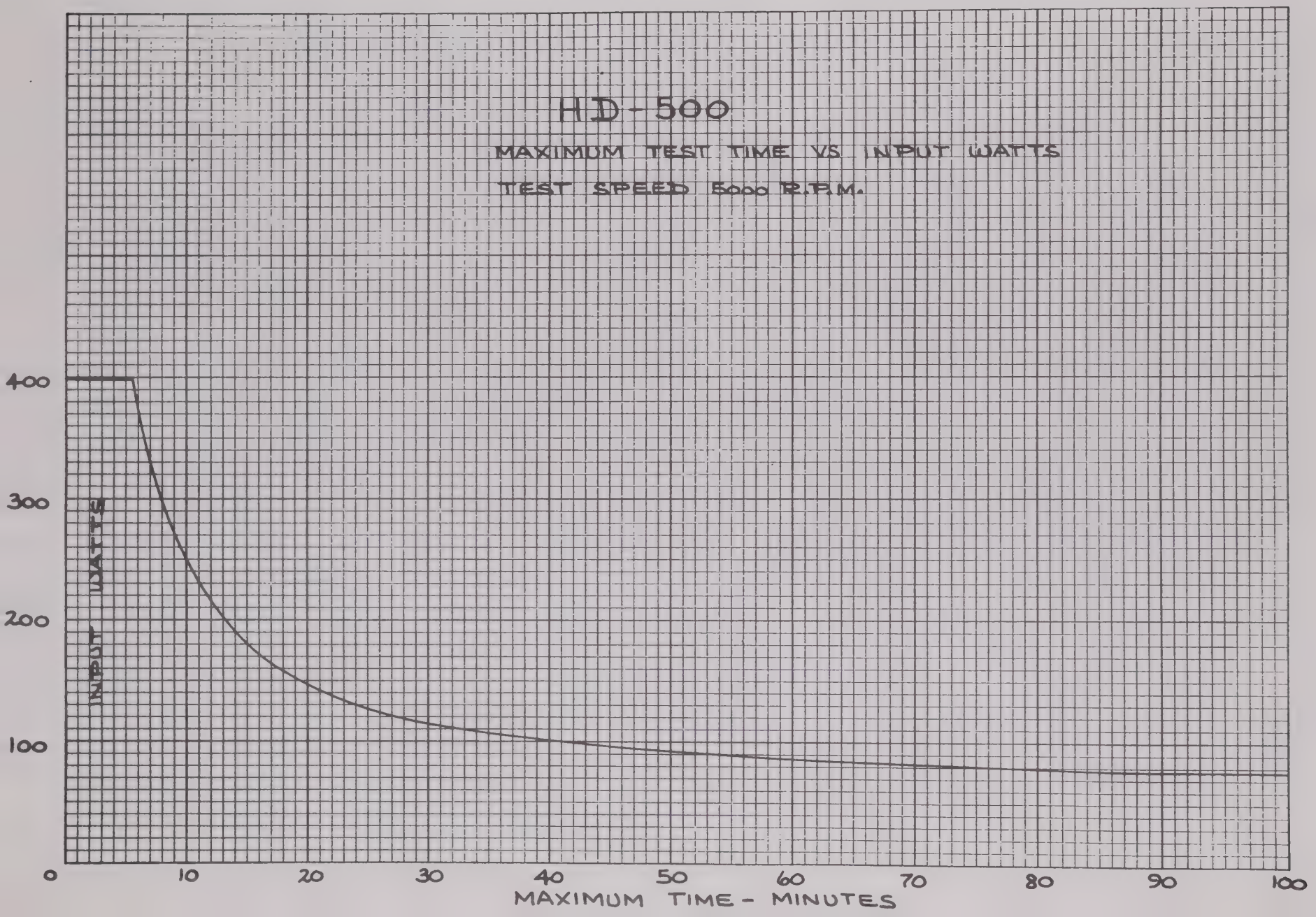

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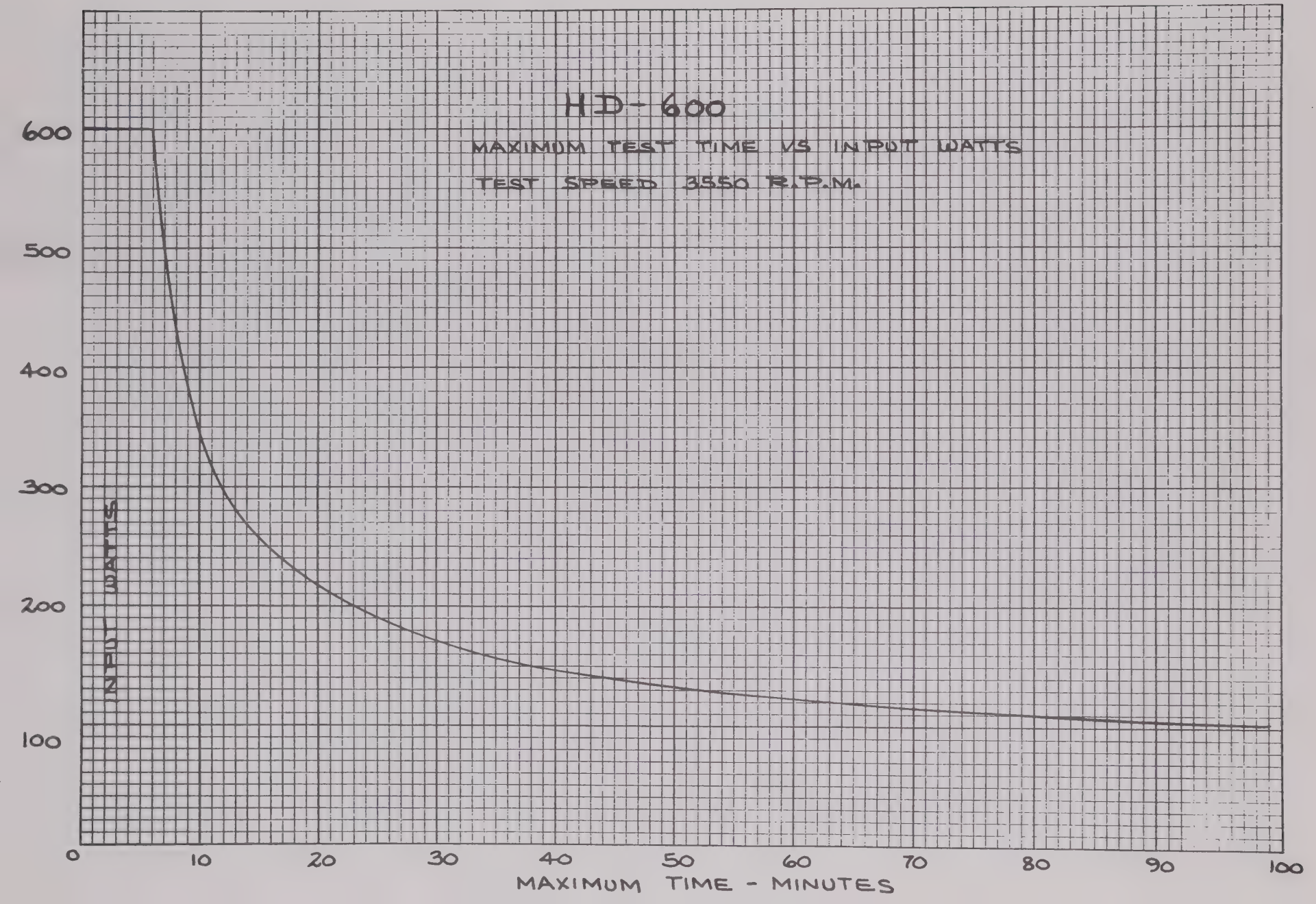

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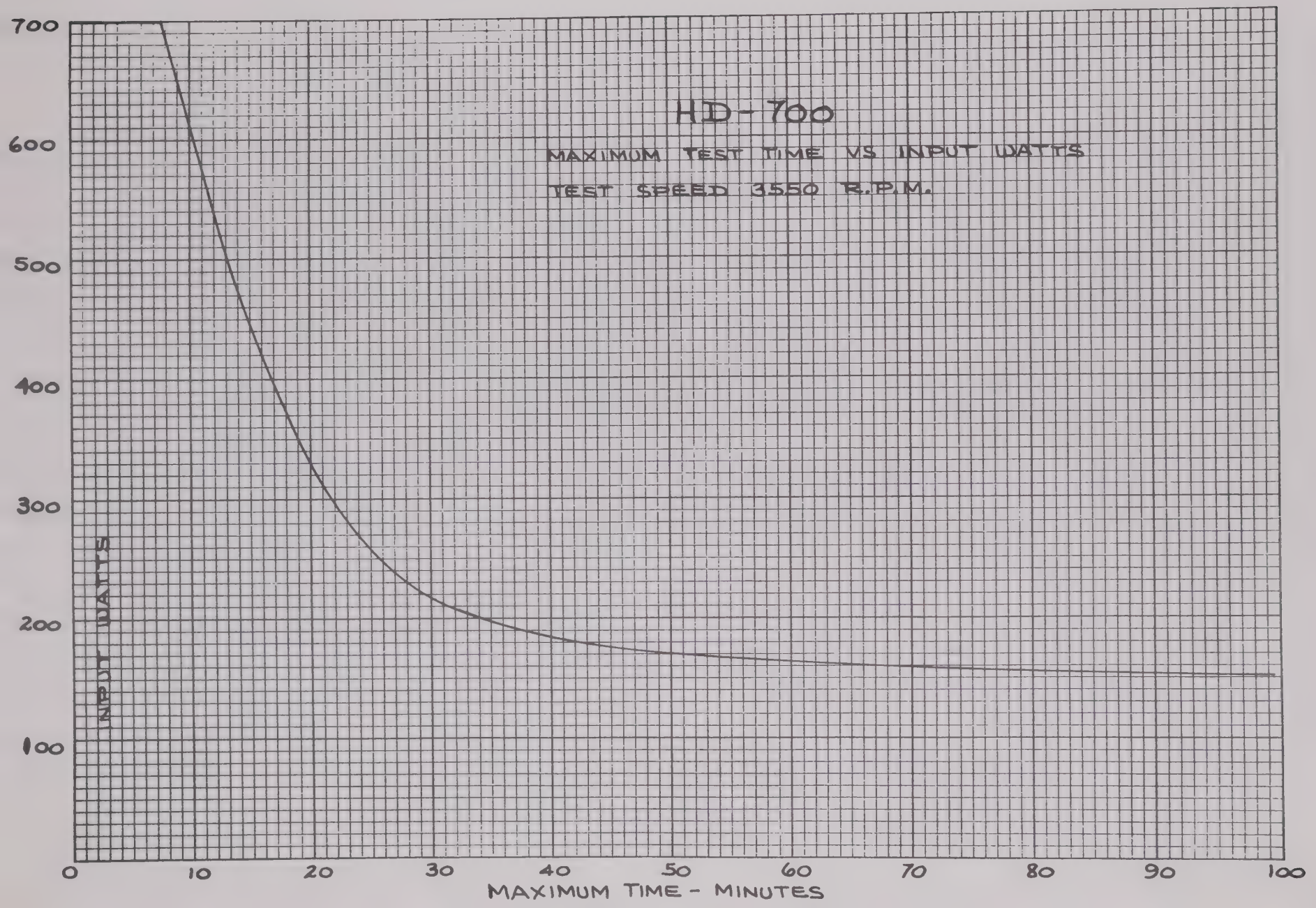

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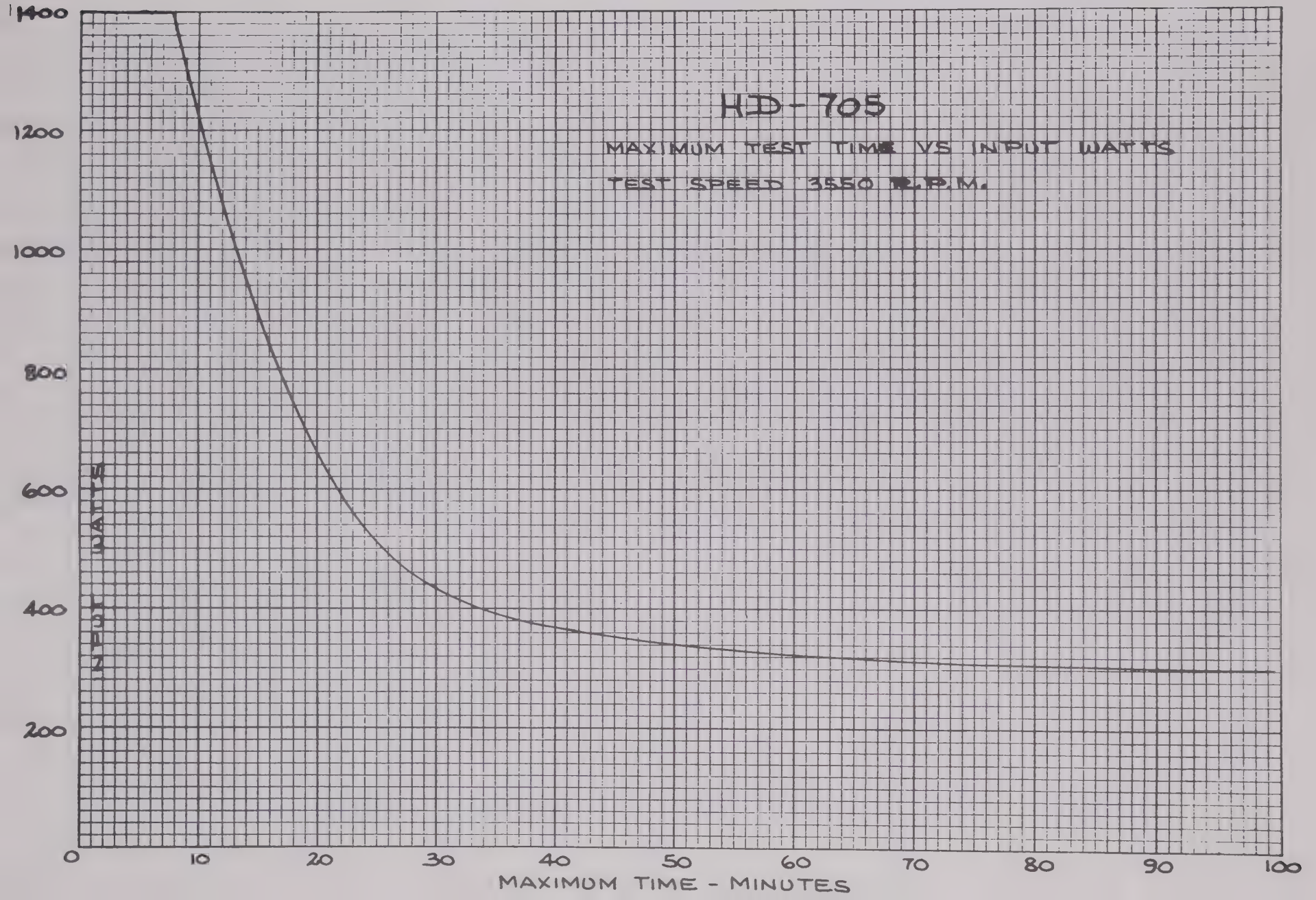

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CHARLES BRUNING COMPANY, INC.
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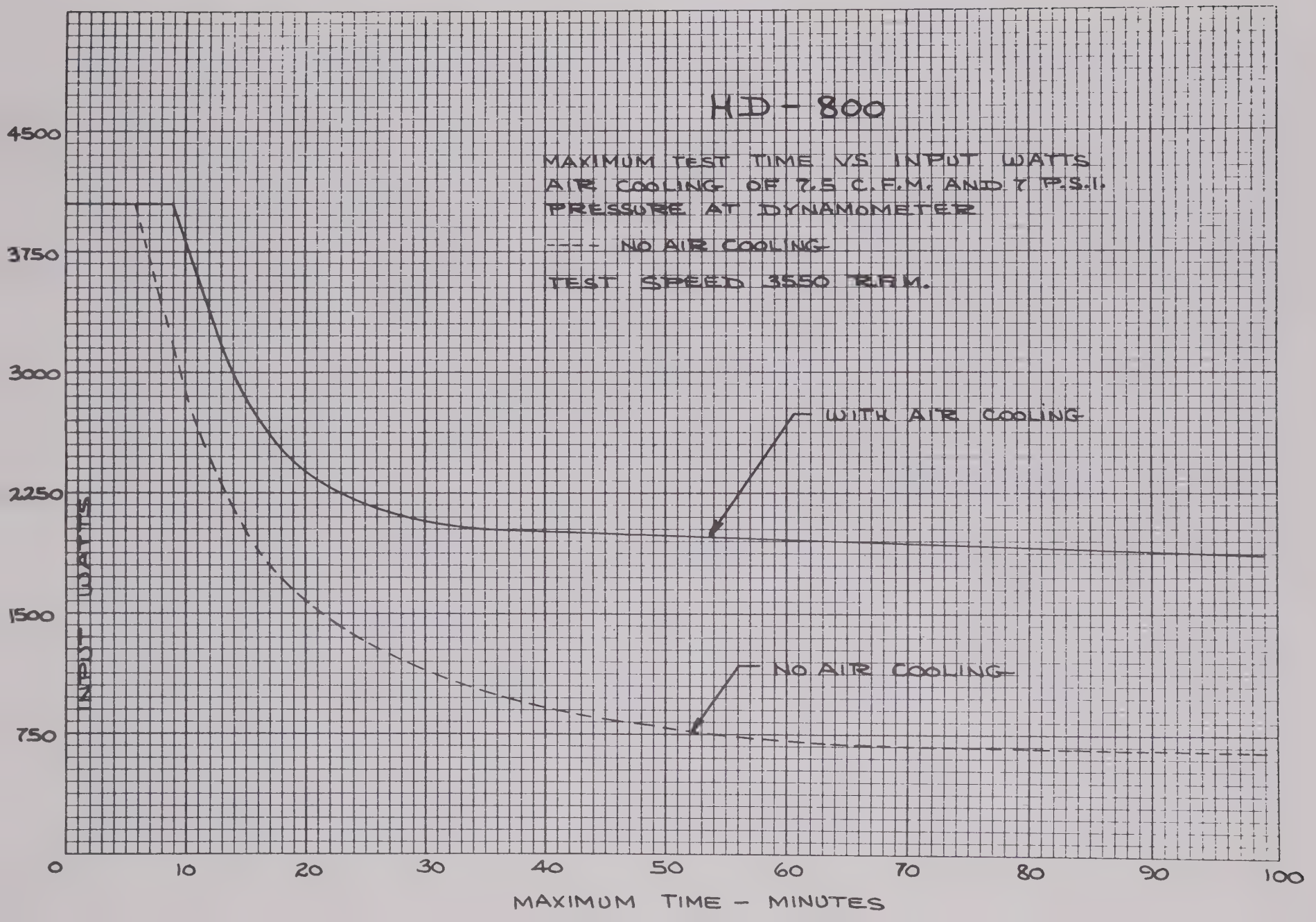

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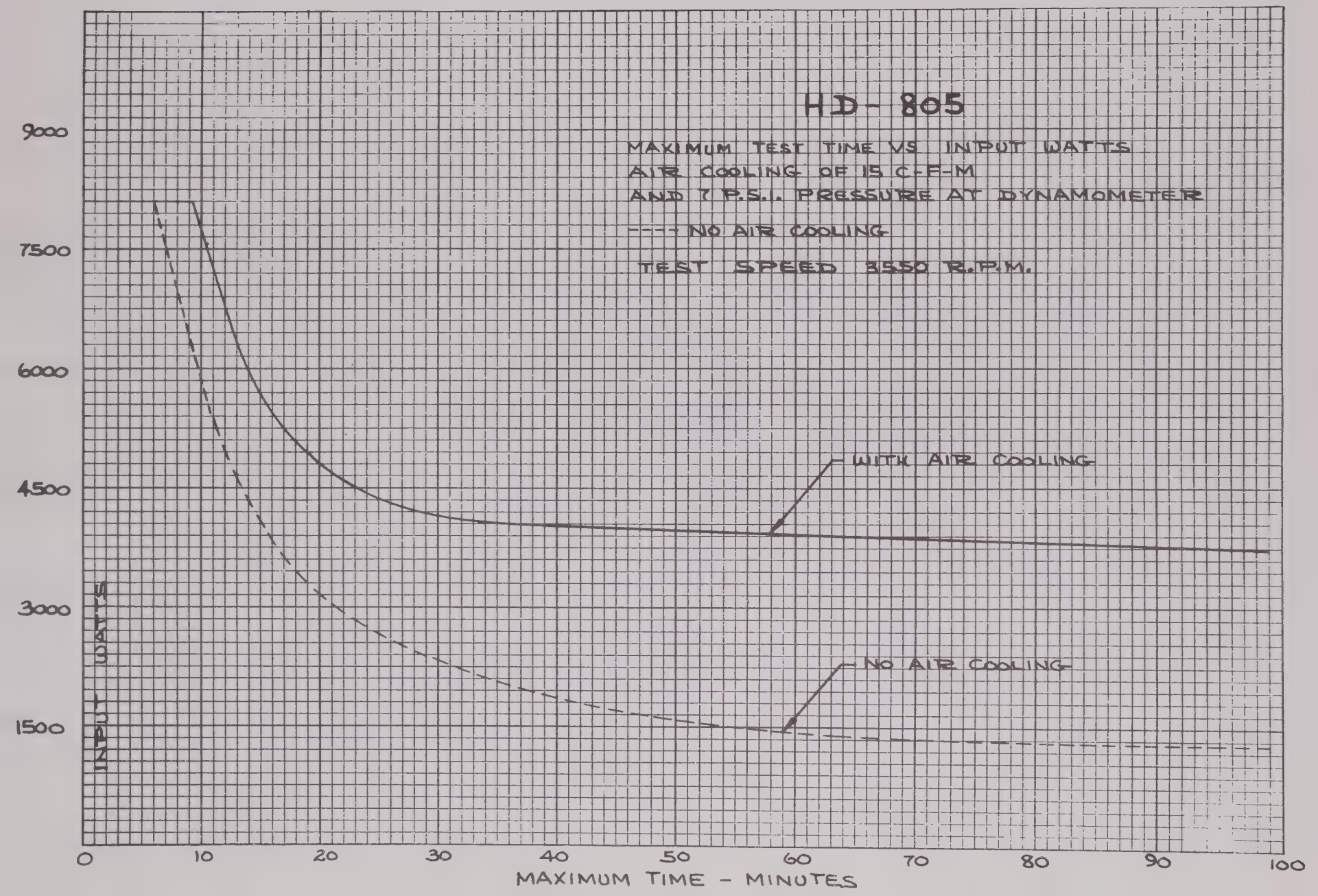


recommended operating temperature.

The HD800 and HD805 have an air cooling system, which greatly increases the power dissipating capability. Refer to the Installation Drawing supplied with this unit for air capacity and requirements. The power absorption curves on these units are shown with and without air cooling. There is no HD106 Power Dissipation Data; since the maximum torque is only 2 oz. in. speed in excess of rating would be necessary to realize maximum recommended temperature rise.

1.7 Maximum Recommended Operating Speed:

The maximum no load speed is dependent on the degree of rotor balance attained on each individual Dynamometer, and the equivalent air gap. Due to normal manufacturing tolerances, each instrument must be tested to establish the maximum safe operating speed. This speed is recorded on a tag with each unit. It contains an automatic 40% safety factor.

1.8 Maintenance:

1.8.1 Lubrication: No lubrication is required since the only rotating friction components are sealed, permanently lubricated, ball bearings.

1.8.2 Cleaning: Do not use cleaning solvents. A moist cloth is usually adequate.

1.8.3. Dis-assembly:
All Models except HD705 and HD805.

1. Remove the Rear Cap.

2. Remove the Light Gate Disc.

3. Unsolder the two Brake Lead Wires terminating at lower edge of the phenolic block, and remove block and cable assembly.

4. Remove the hairline at the top of the upright plate.

5. Remove the two (2) screws holding the front Pillow Block.

   Note: On the HD800 or HD805 models, the front and rear pillow blocks are doweled to the base plate. Proceed as above, except remove bolts of both front and rear pillow blocks, and lift entire brake assembly straight up from the base plate.

6. The entire Brake Assembly may now be withdrawn from the front plate.

7. Remove both carrier bearings and clean or replace.

8. Remove the torque dial.

9. Remove the weight assembly.

10. Remove the rear bearing cap and front yoke.

11. The Shaft and Rotor Assembly may now be removed, by first removing the shaft snap ring at the rear of the Brake Assembly.

12. If the Shaft has been bent, or if the shaft is otherwise tight, it will be necessary to press the shaft out of the Brake Assembly. Support the Brake Assembly on the outer flanges of the magnetic case, and press the shaft and rotor out. DO NOT PRESS AGAINST THE ROTOR.

This is as far as the Dynamometer should be dis-assembled without special jigs and fixtures.

Re-Assembly:

The reverse procedure, outlined above, should be followed, with

the additional inspections and adjustments as follows:

1. With a pressure blow gun, clean the gap of the Dynamometer Brake Assembly to free it of any accumulated dust and metal chips.

2. If checking equipment is available, the Shaft and Rotor Assembly should be checked for run-out. With the shaft running true, the maximum allowable run-out on the outside diameter of the rotor should be less than .002.

3. When assembling the Shaft and Rotor Assembly to the Brake Assembly, press the shaft into the rotor so that the axial play of the shaft with the snap ring in place, is from .002" to .004".

4. When feeding the wires through the hole in the rear plate, leave a large loop for the wires to flex. Be sure there are no corners, or sharp edges on which the wires can catch or chafe.

5. Large clearance holes are provided in the Dynamometer base plate for holding the Front Pillow Block. Adjust the position of the front Pillow Block until the Brake Assembly swings free, and will return to zero, using the smallest torque counterweight. The entire assembly should have .030 to .040 axial play.

MODELS HD-705 and HD-805

Both of these units are built using two Hysteresis Brakes, back-to-back, on a single shaft.

Dis-Assembly:

1 - 9 Follow steps 1 - 9 in Section 1.8.3.

10. Remove both yokes from the Brake Assembly.

11. The rear rotor is retained by two 10-32 Dog Set Screws. Loosen and slide the rotor off the shaft.

12. The front rotor and shaft assembly may now be removed. If necessary to press the shaft, do not rest the Brake Assembly on the rotor.

13. The front and rear Brake Stators may now be separated by removing the 3 - 10-32 cap screws. When separating, be extremely careful not to cut or chafe the lead wires passing through the rear Stator Assembly.

This is as far as the unit should be dis-assembled. For further work, the unit should be returned to the factory, or worked only on further advice from the factory. Special jigs and fixtures are required.

Re-Assembly:

Generally, the reverse procedure should be followed, making sure of the mechanical alignment of the wire pockets, lead wire arrangement, etc.

SECTION 2 POWER SUPPLY MODEL 4636

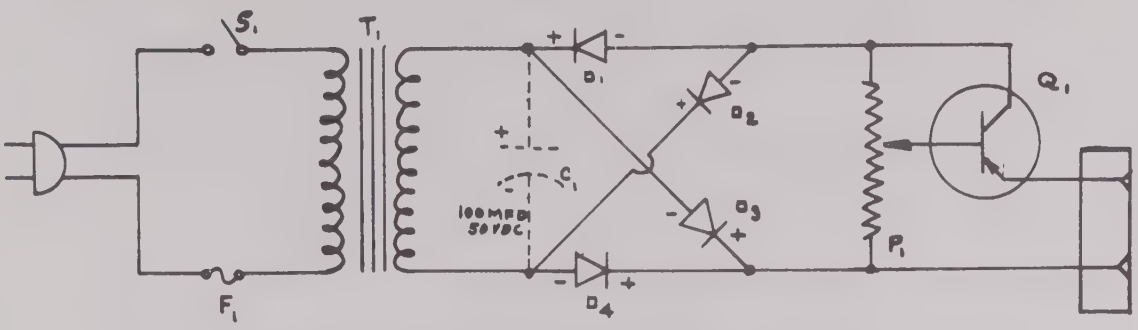
2.1. General Description:

The Dynamometer Brake requires an adjustable current for torque control. This current must be D.C.; however, due to the large inductance of the Brake coil, it need not be pure D.C. The electronic components are housed in an aluminum casting to provide a rugged and durable unit. The unit requires a power source of 117 Volts 60 Cycle Single Phase.

2.2. Circuit Description:

Please refer to Drawing No. 4636. The Dynamometer coil requires a voltage of 0 to 24 V.D.C. This is accomplished by transformer T_1, which reduces the line voltage to 24 V.A.C. D_1 through D_4 are silicon power diodes, which convert the 24 V.A.C. to 24 Volts Direct Current. Potentiometer P_1 permits a voltage source to the "Base" element of Transistor Q_1 to be adjustable from 0 to 24 V.D.C. relative to the common plus side. The "collector" of Q_1 is common to the negative source. Therefore, the "emitter" will follow the adjustable "base" voltage, and with current amplification. The power output is adequate for all Dynamometers, with the exception of the HD805. To increase the power output adequate for this Dynamometer, capacitor C_1 is added, as shown on the drawing. The result is to increase the rectified 24 V.D.C. to a value approaching the peak, or approximately 32 V.D.C. This circuit is protected against short circuit

or component failure by a 2 ampere "slow blow" fuse. This fuse is located in the box and is accessible by removing the bottom cover plate.



Schematic

Bill of Mat'l.

Schematic Identification	Magtrol Part No.	Part Name
⌒	4632	Case – Alum. Casting
P1	6136	CU-502A Ohmite Pot.
⌒	6745	Knob
T1	6770	Triad F-40X Transformer
D1 to D4	6139	3K F2 Rectifier
S1	5853	T-110 Switch
⌒	5874	Buss Fuse Block
F1	5875	1A Slow Blow Fuse
⌒	5877	2005 Term. Strip CJ
Q1	6746	2N508 Transistor
⌒	5918	3/8" Grommet
⌒	6068	CJ 3302-CCT
⌒	6747	Bezel 3M
⌒	5843	Belden Line Cord
⌒	6707	Rubber Feet

LETTER	DATE	BY	ENG'R. CHG. NO.	CHANGE
REVISIONS				

FRACT. ± 1/64 .XXX ± .005
.XX ± .010" ANG ± 1/2°
SURFACE FINISH MICROINCHES

DATE 10-8-63
BY S.T.

Schematic & Bill of Materials For 24 Volt Power Supply

MAGTROL, INC.
240 SENECA ST. BUFFALO 4, N.Y.

DWG. NO. 40 4636

SECTION 4 TACHOMETER PICK-UP

4.1. General Description:

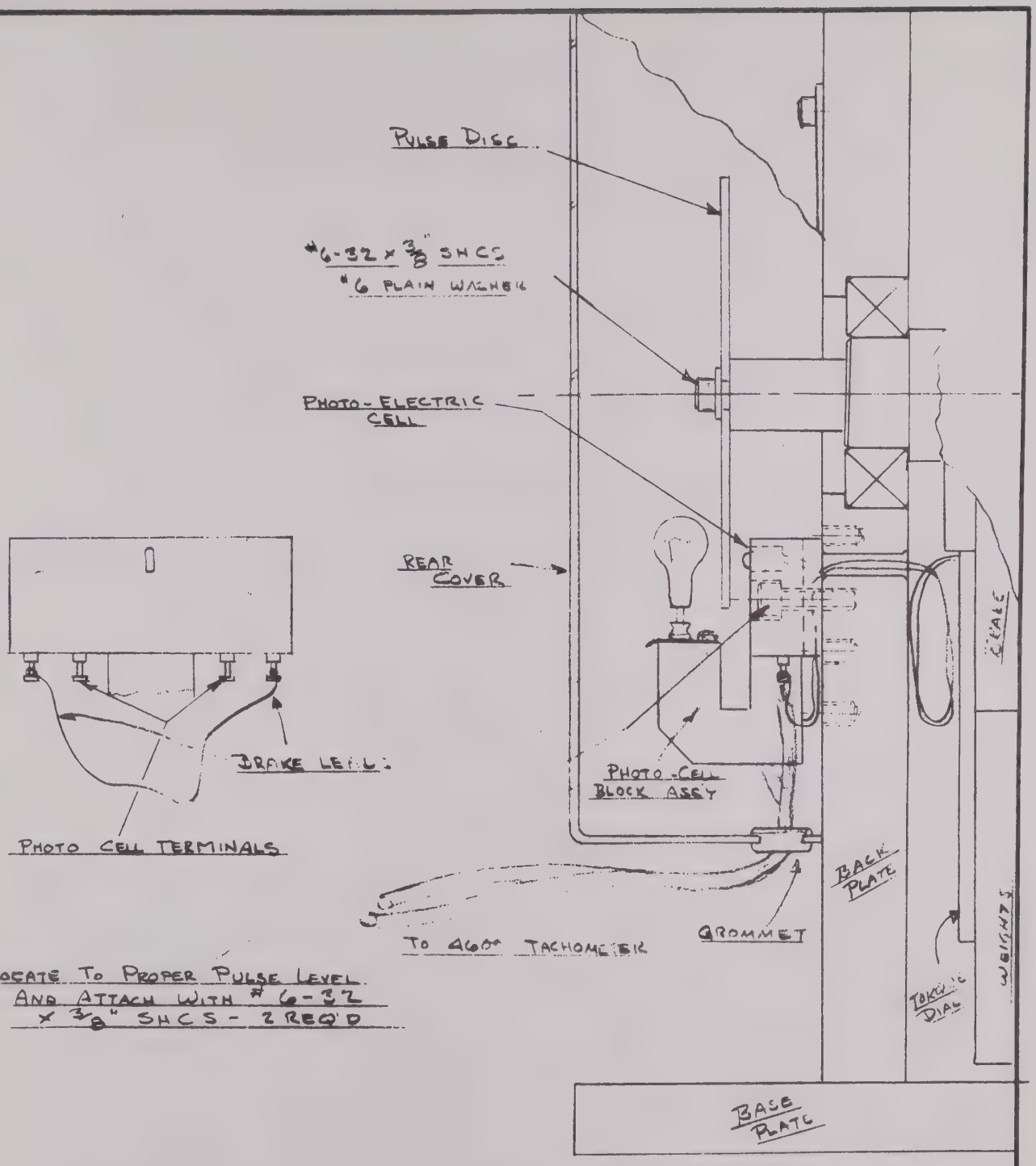
4.1.1. Refer to detailed drawing No. 4140. The principle of operation is the resolution of increments of a revolution by interrupting light falling on a photo-cell. This interruption is obtained from a silk-screen process, which results in opaque and clear bars applied to the surface of a clear plastic disc. The bars form 4 tracks of 60 bits/revolution, 30 bits/revolution, 6 bits/revolution and 3 bits/revolution. As the light to the photo-cell is modulated, the cell changes resistance. The cell is biased by approximately 100 micro-amperes, which then provides a voltage modulation across the cell, proportional to the change in resistance. The wave form output is approximately square at low frequencies, which modifies to a saw-tooth wave form at higher frequencies. The upper range is approximately 30 K.C.

4.1.2. Exciter Lamp:

The exciter lamp is a G.E. No. 12 long life bulb, requiring a D.C. voltage of 5 to 5.5 volts, with a maximum ripple content of 100 millivolts.

4.2. Frequency adjustment:

Referring to the drawing No. 4140, any one of the four tracks are available by removing the 6-32 Socket Head Cap Screws and moving the block to the track required. It is necessary, when making this conversion, to remove the lamp and pulse wheel in order to get at the mounting screws.



LOCATE TO PROPER PULSE LEVEL AND ATTACH WITH #6-32 x 3/8" SHCS - 2 REQ'D

MATERIAL SPEC.	L	W	H	DIA

SCALE	TOLERANCES	SURFACE FINISH
NTS	FRACT.- ±1/64 .XXX -±.005 .XX - ±.010" ANG -±1/2°	XX SURFACE FINISH MICROINCHES

	DRAWN	CHECKED	APPROVED
DATE			
BY			

TITLE: DIGITAL SPEED PICK-UP

MAGTROL, INC.
240 SENECA ST. BUFFALO 4, N.Y.

NEXT ASS'Y

DWG. NO. 40-4140

LETTER	DATE	BY	ENG'R. CHG. NO.	CHANGE
REVISIONS				

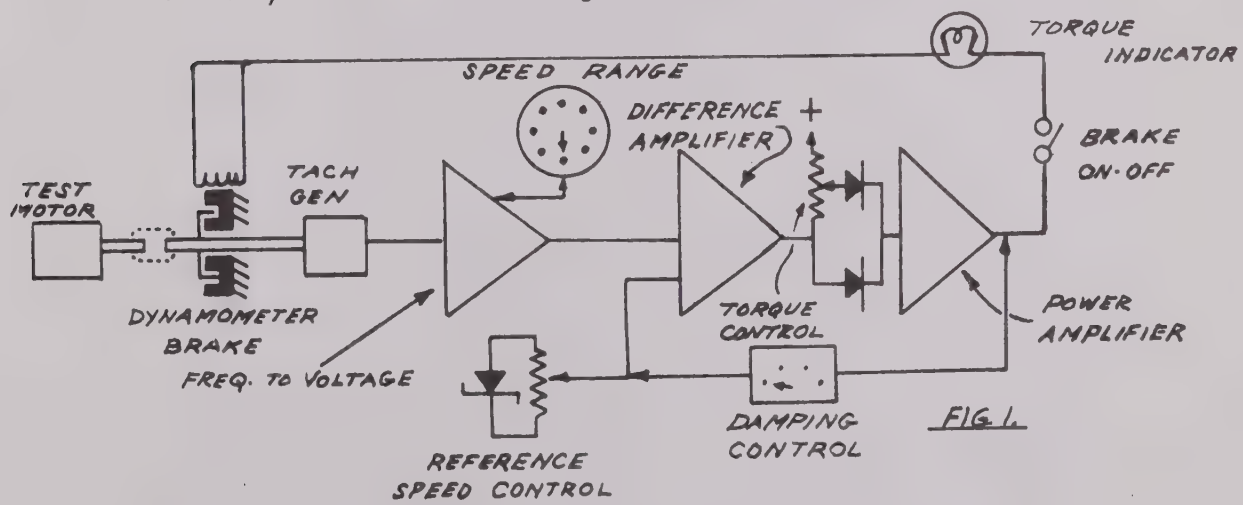
SECTION 5 MODEL 4609 SPEED CONTROLLED POWER SUPPLY

5.1. General Description:

The Model 4609 Power Supply is a speed stabilized servo amplifier. The problem it solves is that of stabilizing a shaded pole, or split phase induction motor in the unstable portion of the torque-speed curve.

To accomplish this, a method must be derived to control the torque on the brake in such a manner that it will not permit the motor to decelerate from the stall point, or "knee" to locked rotor.

The brake has no "speed sense" by itself, but the servo amplifier builds this in by the method shown in Figure 1.



Referring to Figure 1, the operating principle is as follows: A stable reference voltage is set by the "SPEED" control. This level is compared by the servo amplifier, to the tachometer signal, and controls the power

into the brake, proportional to the difference between the Tachometer signal and the reference set. Hence, if the speed tends to rise above a level set, braking torque is applied to slow the motor down. Conversely, if the motor tends to slow down below the level set, the brake load to the motor reduces, allowing a speed increase. This condition is one of stability. Thus, the motor is automatically forced to operate anywhere within the "speed-torque" range.

5.2. The following is a general outline of the controls and their functions:

5.2.1. Maximum Motor Speed:

The "MAXIMUM MOTOR SPEED" selector switch is to be adjusted for whatever R.P.M. range is in excess of the maximum expected motor speed. For example, if the test motor is a four pole 60 C.P.S. and the free run speed is approximately 1785 R.P.M., set the "MAXIMUM MOTOR SPEED" for 2000 R.P.M. The servo amplifier reference, which essentially is the "SPEED" control 3 turn potentiometer, is now prepared to control 2000 R.P.M. down to 0 by rotating in a clockwise direction. Since the maximum shaft speed is not 2000 but 1785 R.P.M., then a dead zone of approximately 1/3 of 1 turn exists, and the potentiometer must be rotated this far before the amplifier functions and begins to apply brake current for control. To remove this dead zone proceed as follows:

1. Switch Brake to "OFF" start motor.

2. Set "Max. Motor Speed" selector for nearest range in excess of the free run motor speed.

3. Set damping control for 1. Rotate the SPEED control clockwise until the Dynamometer Brake Red Light goes "On." Back off (CCW) the control, until the light extinguishes.

Note: If the maximum motor speed is unknown, start with the range switch at a high speed position and proceed as previously outlined. If more than 1-1/2 turns of the "SPEED" control potentiometer is used, without a "red" indication, return the control full CCW and drop down to the next lower speed range; continue this procedure until the correct speed range is obtained.

5.2.2. Speed Control Damping:

It is desirable to increase the stability of the servo amplifier, and reduce the SPEED control sensitivity. This is accomplished by integrating the differential servo amplifier, such that torque cannot be applied rapidly. At position 1 this feed-back is small and is approximately doubled with each successive step to Position 4. Some integration is essential for system stability. On the underside of the unit there is a hole in the bottom plate, which permits accessibility to the stability control. This control sets the over-all level of the damping selector. Too much or too little will result in system instability and oscillation. It may become necessary to adjust this control, when converting from a small dynamometer to a very large unit. (Generally oscillation occurs only in the unstable portion of a torque speed curve). With the DAMPING

selector in Position 1, rotate the control slowly while supporting the dynamometer brake from impacting the stops. The frequency of oscillation will increase until it damps out completely. If the end of the pot is reached before this occurs, set the DAMPING selector on 2 and repeat the procedure.

5.2.3. Stabilized Control:

The dynamometer is prepared to operate with either the speed or torque adjustable and regulated. This is accomplished by controlling the dynamometer with the speed control, or maintaining the torque regulated, by using the torque control, or any combination of the two. The speed control operates as described in paragraph 5.1. The torque control applies regulated current to the dynamometer brake. The fact the torque is then regulated is inherent, since the torque of a hysteresis brake is independent of speed. Refer to Paragraph 1.1.1.

5.2.4. Dynamometer Brake ON-OFF:

The dynamometer brake may be switched "ON" or "OFF" for safety reasons. When the brake is "OFF" the indicator light is still maintained, such that if the power supply is calling for torque a visual indication of this fact is present. It is always safe to switch the brake "ON" if the indicator is out. If for some reason it is desirable

To switch the brake "ON" when the light is on, be sure to restrain the brake assembly on the Dynamometer by hand so that the carriage stops are not impacted.

5.3. Operating Instructions:

Install the two dynamometer plugs, the 2 pin and 6 pin plug, into the 4609 Supply. If a Tachometer is supplied, it has a cord set which allows it to be plugged into the "Tachometer Output" jack provided on the rear panel.

Install the motor to the dynamometer and set the controls as follows:

1. DYNAMOMETER BRAKE SWITCH "OFF".
2. "MAXIMUM MOTOR SPEED" selector to appropriate range.
3. "SPEED" and "TORQUE" controls full CCW.
4. "SPEED CONTROL DAMPING," set to Position 2.
5. Turn Power Supply "ON".
6. Start motor. Allow a moment for the power supply to stabilize.
7. If the red "DYNAMOMETER BRAKE" indicator is out, switch the brake "ON".
8. Rotate the "SPEED" Control until torque is applied and proceed with testing.

NOTE: If in Step 7 the red light does not extinguish, move the "MAXIMUM MOTOR SPEED" to the next highest speed range. Refer to paragraph 5.2.1.

5.4. Maintenance:

Since there are no moving parts in this supply, there is no maintenance required. However, cleaning of the front panel should not be done with solvents. Use a damp cloth.

SECTION 6 MODEL 4634 X-Y PROGRAMMER

6.1 General Description:

This unit is a plug-in section for the Dynamometer Power Supply Model 4609, providing analog output of speed and torque, suitable for recording instruments. Refer to Section 5 for additional information.

6.1.1. Speed:

Speed pick up is accomplished with the use of a Tachometer Generator, mounted on the rear of the dynamometer. The operation of this unit is described under Section 4.

6.1.2. Torque:

The dynamometer supplied with this equipment has the Standard Dial Read-Out. However, to operate the recorder a "Force to Voltage" transducer is necessary. This is a semi-conductor load cell, attached between the dynamometer yoke and base plate. This device absorbs the force, which would normally lift the counter-weight, and develops a voltage linear and proportional to this force which is analogous to torque. The load cell is connected in a bridge circuit configuration, operating a differential amplifier.

6.1.2.1. Effects of Temperature:

Since the load cell is composed of semi-conductor strain gages, the effects of temperature must be considered. With the two gages

utilized in adjacent legs of a full bridge circuit, then the temperature related drift, as seen by the amplifier input, is only differential. Differential drift varies from cell to cell; however, within a given unit, the differential drift is proportional and repeatable to the absolute drift (single element temperature coefficient). A second differential amplifier is incorporated to detect the absolute drift, and provide an independent and adjustable unbalance. This signal is fed back to compensate the differential unbalance of the load cell. Naturally, the two must be precisely matched to utilize this feature to best advantage. The following paragraph outlines this procedure.

6.1.2.2. Load Cell Balance and Compensation Controls:

On the rear of the Model 4634 Plug-in Section are two controls identified as above. The purpose of the 'BALANCE' (screwdriver Adj.) control is to balance the compensating differential amplifier for "O" compensation at the normal room ambient, or at the quiescent condition. Rotation of the COMPENSATION control will have negligible effect when the balance control is set properly under the starting or "cold" condition.

However, if the load cell is heated, due to ambient temperature changes, or more significantly thermal conduction from a "Hot" Dynamometer brake, the compensating differential amplifier will

unbalance. The direction and extent of this unbalance may then be selected by the compensation control to null or re-zero the load cell output.

6.1.2.3. Load Cell Drift Compensation Set Up:

1. Be certain the dynamometer is "de-bumped;" Refer to Para. 1.3 Page 4.

2. Attach the Load Cell, monitor the torque output with X-Y Recorder. Be certain all equipment, except the test motor, has been on for a minimum of 20 minutes and the dynamometer is cool and stabilized at the normal room temperature.

3. Null the torque output by depressing the "ZERO CHECK" push button and adjusting the "ZERO ADJUST" for zero output to the recorder. (Front panel adjustments)

4. With a screwdriver, adjust the balance control on the rear panel, so that when the 'COMPENSATION' control is rotated through approximately 1 to 11, minimum deflection or output occurs. This is a sensitive adjustment, and it may take a few moments and several attempts to bring it in to the minimum. (Adjust the balance slowly.)

5. Position the COMPENSATION CONTROL at exactly No. 6, on the dial.

6. Start the motor, load the motor with torque, which will result in heating the dynamometer and promoting drift. This may take several minutes.

7. Decrease the torque to zero; disconnect the motor power. If drift has occurred, due to temperature rise, the output will not return to exactly zero. Adjust the "COMPENSATION" control, to reset the output to zero. This will add the precise amount of compensation necessary.

6.1.3. Inertial Error Compensation:

When drawing a torque speed curve, it is inherently necessary that the motor be continuously decelerating or accelerating. Therefore, the torque, as seen by the dynamometer, is equal to the true motor torque, plus the inertial torque of all rotating components, but only as speed changes. Therefore, the error generated from the inertia as an additional torque component is proportional to the change in speed. Inertia subtracts when accelerating and adds when decelerating, the quantity depending upon the rate of change of speed. By differentiating the speed signal, it is possible to obtain a signal proportional to the rate of change of speed. This signal is, therefore, proportional to the system inertia. All that is necessary is to obtain the correct quantity, and subtract it from the total or "load cell" torque.

This is accomplished by obtaining the correct level on the "INERTIAL ERROR COMPENSATION" control as follows:

6.1.3.1. Inertial Error Compensation Adjustment:

With the entire system operating, apply a load to the dynamometer with either the SPEED, or TORQUE control. When a stable point is reached, that is, a load with no speed change, drop the recorder

pen and mark the torque speed point. Remove the load. Very slowly rotate the INERTIAL ERROR COMPENSATION, clockwise, re-apply the load fairly rapidly beyond the point previously marked.

Note the relationship of the indicated torque to the true torque, and continue to adjust the INERTIAL ERROR COMPENSATION until the recording rate has minimal effect on the indicated torque.

NOTE:

It is not necessary that any specific recording rate be maintained; once this setting is made correct, the system will adjust automatically. However, system, torque-speed and recorder response will add error to the recorded data if too rapid recording is attempted. It is difficult to specify the maximum recording rate, since this is dependent upon variables, such as motor inertia, type of recorder, dynamometer size, top speed, etc.

6.2. Set Up and Operating Procedure:

With all equipment off, connect all cord sets and plugs as follows:

1. Dynamometer to programmed power supply.
2. Cord set from torque output to "X" axis. Red or plus terminal to red or plus terminal on recorder.
3. Cord set from speed to "Y" axis as in .2. above.
4. Black "ground" cord to recorder chassis.

Turn recorder "on," and set controls as follows:

5. Gain controls (if applicable) to a sufficient value for minimum recorder hysteresis.

6. Set filtering for max. (if applicable).

7. Set "X" and "Y" axis position for pen in lower left hand corner.

8. Set inputs for "Y" (speed) axis variable and select input for approximately 10 volts F.S. Some external means is necessary for measuring speed for calibration. The speed signal is linear, proportional and repeatable, but uncalibrated.

9. Set X Axis for highest scale input voltage.

10. Turn recorder stand-by switch "OFF."

Dynamometer:

Install motor, but do not couple shafts. Determine the directions of rotation of the motor, facing the shaft.

11. Connect load cell to yoke with thumb screw provided. Also attach the calibration beam provided to the yoke.

X-Y Power Supply, MODELS 4609 And 4634:

12. With master switch "off," switch "Shaft Direction." Switch to "CW" or "CCW," as determined above.

13. Torque and Speed Controls full CCW.

14. Dynamometer Brake Switch "OFF."

15. Set SPEED CONTROL DAMPING to No. 3 position and CONTROL RANGE SELECTOR SWITCH to a speed equal to or greater than the maximum expected motor speed. Refer to Paragraph 5.2.1. Section 5.

16. Turn Power Supply Master Switch on.

17. Switch the Servo Switch on the recorder "ON."
Position pen in the lower left hand corner. "X" axis master selector to low sensitivity position, range selector set for variable input. Be sure pen is positioned precisely on "O", both axis.

18. Press "Null Test" button repeatedly, and observe if pen moves on "X" axis; if so, adjust "Null Set", until no movement occurs when depressing "Null Test." Set recorder input level selector to next most sensitive range; and repeat the above. Continue this procedure until a true null has been obtained, down to at least 1 volt range. Reset the range switch to 5 to 10 volt range.

19. Calibrate the load cell by placing a weight on the beam, so that the force is in the correct direction of rotation. The beam is provided with a hole suitable to retain a wire or hook which may be fashioned on the weight. This hole is located and identified a precise distance from the shaft centerline,either 5, 10, or 20 inches, depending on the dynamometer model. This distance in inches, times the value of the weight, is equal to the applied torque. Adjust the recorder input level to a suitable scale.

20. Remove the weight and repeat Step 18 until a precise calibration is obtained.

21. Couple the motor to the dynamometer.
Note: The quality of the recording will be no better than the coupling accuracy. Eccentric or misaligned shafts result in torque pulsations and coupling losses, which are detrimental to accuracy.

22. With the dynamometer brake switch "OFF", start the motor and calibrate the speed by first determining what the true speed is with a suitable tachometer. Then adjust the X-Y recorder axis for a logical scale, such as 100, 500, or 1000 R.P.M. per inch or as required.

23. Motor off.

24. Depress "ZERO TEST." If drift has occurred, reset the "O" with "ZERO ADJUST."
Note: Never set "O" with recorder position control, or level control to correct for drift. This must be accomplished by the "ZERO ADJUST" control, on the programmer. It is unnecessary to recalibrate if drift has occurred, since the basic calibration is inherently unaffected by this. Note: Motor should be "OFF."

25. Start motor. Dynamometer indicator Light should be out. Do not turn brake on, if red light is on. It may take a moment for the light to extinguish. Refer to Paragraph 5.2.1.

26. Drop pen, rotate "SPEED CONTROL" slowly and draw curve. Brake indicator should go "Red."

27. For inertial cancellation refer to paragraph 6.1.3.1.

6.3. Oscillations or Eratic Behavior:

6.3.1. If the X-Y recorder and the dynamometer are in close proximity on a loose mounting, such as a table that shakes, they can "cross talk," or feed back. The only solution is separation, or a more solid mounting.

6.3.2. At a very few R.P.M. motors typically "cog" due to slotting and/or brush effects. This may induce torque pulsations, causing moderate or even violent horizontal jerking of the recorder. Since it is inherent in motor design, there is no solution from the equipment standpoint. The best thing is to lift the pen unless the information is desired. Also, below approximately 100 R.P.M., the equipment, as a servo, becomes unresponsive due to practical limitations.

6.3.3. Mechanical alignment or motor coupling is important. Poor couplings, and/or alignment, results in torque differences within one revolution of the shaft. The recorder will respond to this with "jitter."

6.3.4. Since the dynamometer with the standard weight system is an unbalanced mass, it is best when X-Y recording to remove the counter weights. This lessens the tendency to pick up mechanical vibration. In addition, two filters are available one for each of the X-Y axis. These reduce

torque and speed pulsations for a smoother recording line, at some sacrifice to recording speed. An important thing to remember is that motors typically do not rotate without speed pulsations produced within a revolution. The extent depends upon such things as rotor inertia, shaft concentricity, number of poles, and balance. The servo amplifier and X-Y recorder are necessarily capable of picking pulsations up. Therefore do not be surprised if the torque-speed curve is modulated with a carrier of up to a few per cent, on some types of motors.

6.4. Alignment:

There are a group of trim pots located on the circuit boards internally. These are all factory pre-set and future need for adjustment is not indicated. In case of difficulty consult the factory.

MAGTROL WARRANTY

MAGTROL, INC. warrants that any equipment of our manufacture will be free of manufacturing or design defects, to the extent that we will unconditionally guarantee equipment for a period of 90 days from date of receipt by the customer.

ADDITIONALLY, on any repairs, which may become necessary beyond the 90 Day Unconditional Warranty period, these will be made, subject o complete review by our Quality Control and Engineering Department, to determine the portion of cost to be apportioned between Customer and Magtrol, Inc., dependent on our evaluation of faulty design or workmanship claims.

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